Fresh Water

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BACKGROUND

Although water covers nearly three-quarters of Earth's surface, only 3% is freshwater in some form. Most of that small fraction is found in glaciers or is underground—only a tiny percentage of the world's freshwater occurs as surface water. Canada is more fortunate than most countries because the country's landmass contains approximately 9% of the world's renewable water supply (water replenished by precipitation on a short-term basis) (NRCan 2006). This may sound like a great deal of water, but concern about water quality and supply is increasing with the increasing demand on water resources by a growing population and the effects of climate change on precipitation patterns and glacial melting.

A clean and adequate water supply is a necessity for the health of all living organisms and ecosystems, including people and their activities. Fresh water supports the agriculture, fisheries, and forests on which society depends for food, clothing, and shelter, as well as for recreational and cultural pursuits.

Indicators in this paper focus on three aspects of fresh water in British Columbia: surface water quality, groundwater supply and water use. They are indicators of the need for, and progress in, action on water resource stewardship to ensure the future sustainability of water resources.

INDICATORS

1. Key Indicator: Water quality index for surface water bodies in B.C., 2002–2004

The quality of surface fresh water, as measured by the Water Quality Index (WQI) is a state or condition indicator. The WQI is a tool that allows a large number of water quality characteristics for a particular body of water to be expressed as a simple rating. It shows the overall quality of a water body in relation to the uses for that water, such as habitat for aquatic life, irrigation, recreation, or drinking water. The first WQI was developed in British Columbia in 1995. An interjurisdictional committee of water quality experts adapted the index for use nationally through the Canadian Council of Ministers of the Environment (CCME 2006). In general, this tool helps to answer the question: How good is the water quality?

Water quality variables are numerical measurements of the physical, chemical, and biological characteristics of water. Variables include physical characteristics, nutrients, metals, major ions, and other compounds such as pesticides. Guidelines for the different variables have been established through research. When these guidelines are exceeded, there is a risk of adverse effects.

Not all variables are measured—or are relevant—for every water body sampled. Different subsets of variables apply to different sites, according to the water quality objectives for the site.

"Water quality objectives" are limits set for water quality characteristics by the Ministry of Environment or by Environment Canada to protect all designated uses of a specific water body. The objectives take into account the local water quality conditions and uses and establish a reference against which the state of water quality in the water body can be measured. "Guidelines" are safe levels of water quality characteristics that apply province-wide or nationally to protect sensitive uses of water such as drinking, aquatic life, agriculture, and recreation. Guidelines are used when objectives have not been established for a water body; they provide a general reference against which the state of water quality can be checked.

The water quality index is a measure of how the water quality variables compare to the water quality guidelines or objectives for a specific site. The results of the comparisons for the relevant variables are combined to provide a water quality ranking for an individual water body.

Results reported in this indicator are not exactly comparable to WQI results reported in previous Environmental Trends in British Columbia: 2002 and therefore data from this indicator cannot be compared with earlier reports to show trends.

Methodology and Data

The WQI combines three aspects of water quality relative to water quality objectives:

- **Scope:** The number of variables that do not meet objectives in at least one sample during the time period under consideration, relative to the total number of variables measured.
- **Frequency:** The number of times that individual measurements do not meet objectives, relative to the total number of measurements taken in the relevant time period.
- **Amplitude:** The amount by which measurements that do not meet the objectives actually depart from those objectives.

These three factors are combined to form a numerical rating for a water body that falls into one of the five categories described below. These rankings describe the state of the water quality compared to the desirable or natural state for that water body.

Rating scale used for the CCME Water Quality Index (CCME 2006)

Excellent	95 to 100	Conditions are very close to natural or pristine levels. These index values can be obtained only when measurements never, or very rarely, exceed water quality guidelines.
Good	80 to 94	Water quality is protected with only a minor degree of threat or impairment. Measurements rarely exceed water quality guidelines and, usually, by a narrow margin.
Fair	65 to 79	Water quality is usually protected but occasionally threatened or impaired. Measurements sometimes exceed water quality guidelines and, possibly, by a wide margin.
Marginal	45 to 64	Water quality is frequently threatened or impaired. Measurements often exceed water quality guidelines and/or by a considerable margin.
Poor	0 to 44	Water quality is almost always threatened or impaired. Measurements usually exceed water quality guidelines and/or by a considerable margin.

Selection of water bodies: Water bodies were selected for monitoring if they were generally pristine or received industrial, municipal, or agricultural discharges and were therefore potentially at risk of being polluted. Monitoring focuses on water bodies that are likely to become, or already are, affected by human activities. It is important to note that most of the thousands of water bodies in the province are not monitored.

Sampling frequency and timing: Water samples are collected at times of the year when the water quality threshold is most likely to be exceeded. The WQI rating is based on the attainment of water quality objectives during these critical months.

To be included in calculations, the minimum requirement for lakes was 6 samples taken between 2002 and 2004; for rivers, it was at least 12 samples. In practice, most sites were monitored at least twice a month. This higher monitoring frequency has been shown to increase the chances of measuring concentrations that are higher than the water quality objectives.

Water quality characteristics: The range of measurable water quality variables includes nutrients, metals, physical characteristics (e.g., pH, dissolved oxygen, turbidity, and suspended solids), major ions (e.g., chloride, sulphate), and other compounds. Water quality characteristics measured at a given sampling station can include any of the following: levels of nitrate, fecal coliforms, cyanide, total dissolved gases, dissolved oxygen, suspended solids or sediments, nutrients, zooplankton, algae, trace metals, major ions, pH, and temperature.

Establishing the WQI: Acceptable threshold levels or concentrations are set for the water quality characteristics measured for each water body monitored. These levels depend on the water uses identified for the water body, such as drinking, recreation, irrigation and livestock watering, and use by aquatic life and wildlife. Note that drinking water in this context always refers to the quality of the source water before any treatment, before it is delivered to a consumer's tap (even if raw water is rated as excellent, it always goes through purification processes such as disinfection before distribution for drinking).

For the 2002–2004 reporting period, the focus was on determining the rating for each water body for the protection of only one water use—habitat for aquatic life, which is the most sensitive use for most water quality variables. Using the same set of objectives for one use (aquatic life) for all water bodies overcomes a problem with past reporting, which was that ratings for water bodies were not comparable because they protected different uses and therefore used different objectives.

Calculations were made using an index calculator available on the CCME website at *www.ccme.ca/ourwork/water.html?category_id=102*. For the period considered, the user supplied the data and the site-specific objectives. Using the calculator, the following were determined for each site: the number of variables that did not achieve the objective at least once, the number of times and places that the objectives were not met, and the largest amount by which any objective was not met. Methods used in the calculations are outlined in the Canadian Water Quality Guidelines for the Protection of Aquatic Life: CCME Water Quality Index 1.0 User's Manual (CCME 2001) (*www.ccme.ca/assets/pdf/wqi_usermanualfctsht_e.pdf*).

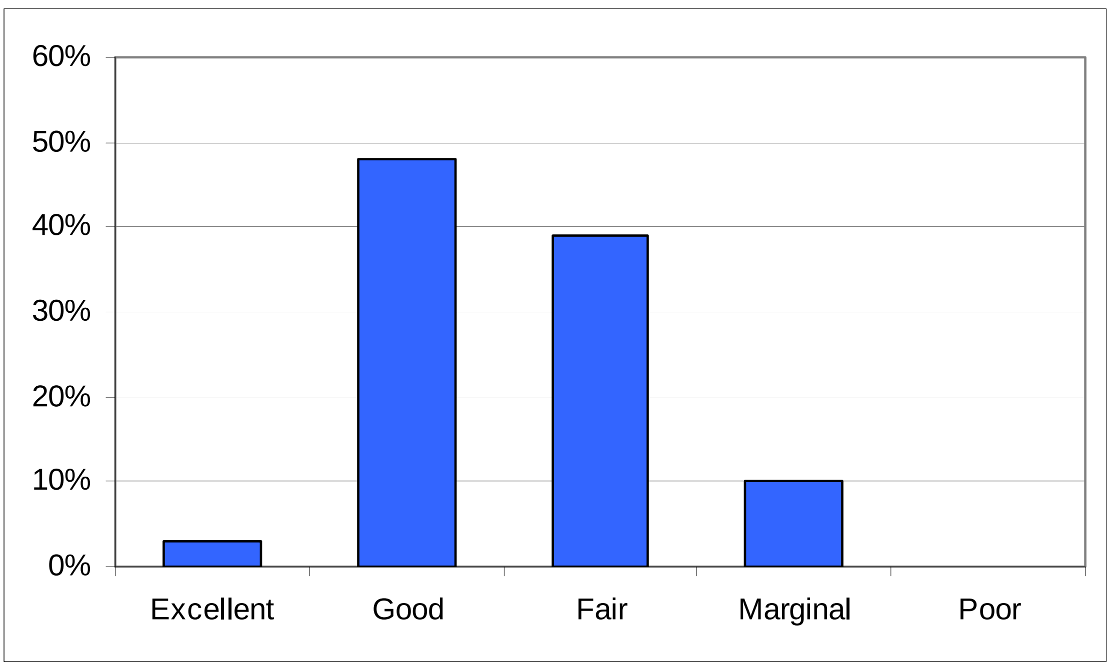
Caveats:

Index comparisons should be made only when the same sets of objectives are being applied for the water body and only when measuring the same sets of variables. The index should be based either on site-specific objectives or on guidelines for variables that have been ranked as the most important and relevant for the site. Including irrelevant variables can give unrealistically high (i.e., better) index values.

The WQI rank for a water body is sensitive to the number of water quality objectives, so generally a minimum of about eight objectives were applied to each water body. Where there are a greater number of threats to water quality, using a greater number of additional objectives (such as nitrate, ammonia, dissolved oxygen, bacteria, etc.) produces a more stable rank.

The WQI was calculated for 31 water bodies, including streams, rivers, and lakes, for which sufficient data were collected between 2002 and 2004 (Figure 1, Table 1).

Figure 1. CCME Water Quality Index ranks for sites in B.C., 2002–2004, as a percentage of the 31 sites tested.



Source: BC Ministry of Environment

View graph data in excel.

Table 1. CCME Water Quality Index ranks for sampling sites in B.C., 2002–2004.

Location	Score	WQI rank
Beaver River near East Park Gate	88.4	Good
Columbia River at Birchbank	87.2	Good
Columbia River at Waneta	80	Good
Elk River at Highway 93 near Elko	73.2	Fair
Elk River at Sparwood	65.1	Fair
Fraser River at Hansard	82.7	Good
Fraser River at Hope	84.2	Good
Fraser River at Marguerite	74.2	Fair
Fraser River at Red Pass	100	Excellent
Illecillewaet River at Park Entrance	82.6	Good
Iskut River below Johnson River	91.7	Good
Kettle River at Carson	71	Fair
Kettle River at Midway	76.7	Fair
Kicking Horse River above Field, BC	87.2	Good
Kootenay River at Creston	71.1	Fair
Kootenay River at Kootenay Crossing	88.5	Good
Kootenay River near Fenwick Station	67.9	Fair
Myers Creek at International Boundary	65.2	Fair
Nechako River at Prince George	92.8	Good
Okanagan River at Oliver	70.8	Fair
Peace River above Alces River	84.2	Good
Pend'Oreille River at Waneta	85.3	Good
Quinsam River near the Mouth	65.3	Fair
Salmon River at Hyder	61.1	Marginal
Salmon River at Salmon Arm	45.8	Marginal
Similkameen River at Princeton	83.2	Good
Similkameen River near International Border	82.7	Good
Skeena River at Usk	82.7	Good
St. Mary at Wycliffe	60.2	Marginal
Sumas River at International Boundary	68.1	Fair
Thompson River at Spences Bridge	65.2	Fair

Source: BC Ministry of Environment

Results show that 51% of B.C. water bodies tested (2002–2004) were classed as either Excellent or Good, 39% Fair, only 10% Marginal, and none Poor. This compares favourably with the national breakdown for the same period, where 44% of water bodies were classed as Excellent or Good, 31% Fair, and 25% Marginal or Poor. However, this does not necessarily mean that water quality in B.C. is better than the national average. The national average could be skewed depending on the number and location of the water bodies selected for monitoring in each jurisdiction. It would also depend on whether jurisdictions used generic guidelines as objectives instead of site-specific water quality objectives that were used in B.C.

It is not possible to determine if there are trends in the WQI scores for individual sites in comparison to past years since new objectives were developed to ensure that scores were applied consistently across all sites. As well, data were not available for some sites used in the past and new sites have been added for reporting. Monitoring will continue at most of these sites and will eventually provide trends in water quality in future.

2. Secondary Indicator: Trends in surface water quality in B.C.

The trend in water quality for selected water bodies, over time, is a status or condition indicator. In general, it addresses the question: Is the water quality improving or decreasing?

The quality of water is a major concern because of the impact it has on the suitability of water sources for human and natural uses. This indicator shows the direction of departure (if any) of water quality from an acceptable threshold for each water body. The environmental significance of each trend is assessed in relation to water quality objectives for each water body or to province-wide water quality guidelines.

Methodology and Data

Environment Canada and the B.C. Ministry of Environment have been collecting technical data on surface water quality for many years through the Canada–B.C. Water Quality Monitoring Agreement. Data are from a network of water sampling stations throughout the province. (Many of these sites are the same monitoring stations used for the Water Quality Index described in Indicator 1.)

Selection of water bodies: Greater efforts are being made to monitor water bodies in areas of high human activity; therefore, the water bodies selected tend to represent water quality in developed watersheds around the province. That means that overall trends should not be considered as representative of water quality trends in the province as whole.

Sampling frequency and timing: Depending on the type of water body, sampling is carried out weekly, biweekly, monthly, or annually. Most rivers are monitored biweekly. Lakes and streams are usually monitored at least once per month, although some lakes may be monitored once per year, in the spring when the water is well mixed. Bottom sediments are less variable than surface waters and can be sampled annually or even once every few years.

Water quality characteristics: For a given water body, water quality measures can include some or most of the following: levels of nitrate, fecal coliforms, cyanide, total dissolved gases, dissolved oxygen, suspended solids or sediments, nutrients, zooplankton, algae, trace metals, major ions, pH, and temperature.

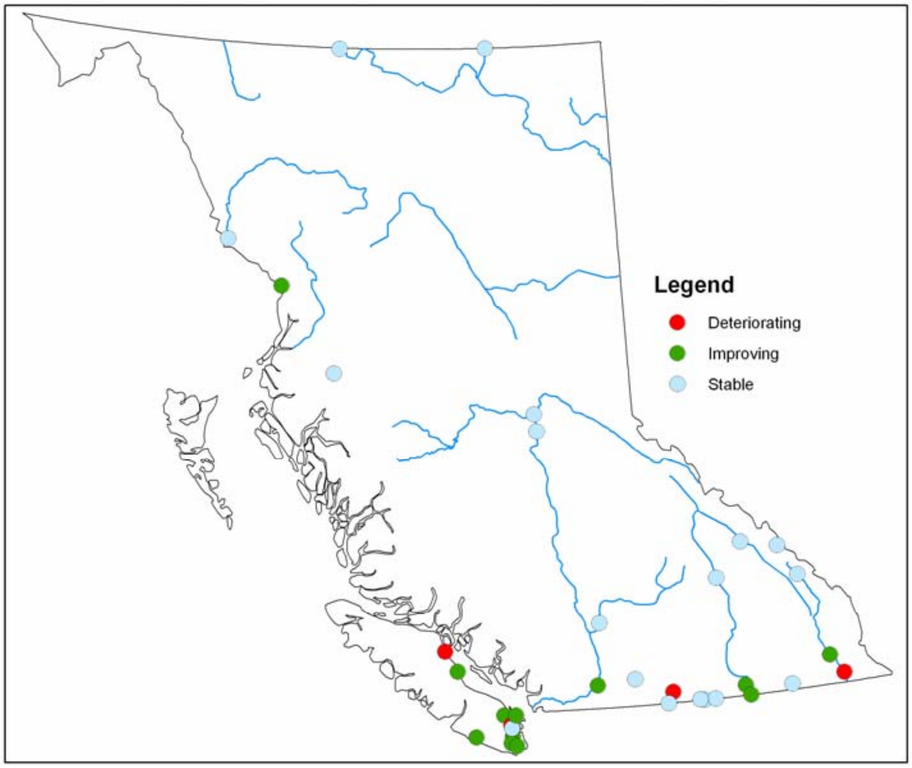
Analysis of trends: Trends were determined by plotting water quality measurement values on a graph over time together with the relevant water quality objectives or guidelines. Water quality objectives are limits set for water quality characteristics by the Ministry of Environment or by Environment Canada to protect all designated uses of a specific water body. Objectives take into account the local water quality conditions and uses and establish a reference against which the state of water quality in the water body can be measured. Guidelines are safe levels of water quality characteristics that apply province-wide or nationally to protect sensitive uses of water such as drinking, aquatic life, agriculture, and recreation. Guidelines are used when objectives have not been established for a water body to provide a general reference against which the state of water quality can be checked.

After the water quality values were plotted, the graph was inspected for significant trends with respect to environmental conditions. Trends that were increasing or decreasing over time and that appeared to show an important change in water quality were checked to determine whether the trend was a result of measurement errors, to test for statistical significance, and to identify the cause of any real change.

The condition of each water body was classified into one of three categories (Improving, Stable, Deteriorating) according to the trend in water quality for that site compared to water quality objectives or guidelines and are listed in Figure 2 and Tables 2, 3, and 4. Note that within each category, there is no ranking to account for the amount by which a water body had departed from the objectives or guidelines. Where other concerns for water quality were identified, these were so noted.

Trends in surface water quality are based on regular and consistent long-term monitoring. Of the 38 stations on water bodies included in this analysis (Tables 2 to 4), most have at least 10 years of data collected between 1980 and 2000 (or later, in some cases), and some have more than one sampling station. Before 2000, about 17 monitoring stations were terminated; most had no water quality concerns or the concerns were related to natural conditions. Twelve new stations were added between 2002 and 2006 (listed in Table 5). The new stations do not yet have enough records to show trends, but in future years will provide data for trend reporting. One station was terminated since reporting in 2002, Myers Creek (1998–2002), because a proposed mine in the United States that could have affect water quality has not proceeded; monitoring will resume if the proposal proceeds.

Figure 2. Trends in water quality at monitoring stations in B.C.



Source: B.C. Ministry of Environment 2007. Data from Tables 2 to 5, below.

Table 2. Water quality monitoring stations in B.C. showing improving water quality.

Location of monitoring station (years of records)	Water quality concerns monitored	Cause of trend	Water use at risk
Columbia River at Birchbank (1983–2000)	Iron, aluminium	Dams/reservoirs	Drinking water, aquatic life
Columbia River at Waneta (1983–2000)	Cadmium, iron, chromium, lead, zinc, fluoride, sulphate, phosphorus	Waste abatement	Aquatic life, drinking water, irrigation, recreation
Cowichan River (1999–2003)	Phosphorus	Waste abatement	Drinking water
Fraser River at Hope (1979–2004)	AOX, Chloride	Waste abatement at pulp mills	Aquatic life and human and wildlife consumption of aquatic life
Fraser River at Marguerite (1985–2004)	AOX, Chloride	Pulp mill waste abatement	Aquatic life, wildlife, and their human consumers.
Fraser River at Red Pass (1985–2004)	Lead	Removal from gasoline	Aquatic life, drinking water
Kootenay River at Fenwick Station (1991–2000)	Zinc	Waste abatement	Aquatic life
Langford Lake (1979–98)	Phosphorus	Lake aeration and unknown	Aquatic life, recreation.
Lizard Lake (1985–95)	Phosphorus	Unknown	Aquatic life, recreation.
Maxwell Lake (1985–95)	Phosphorus	Unknown	Drinking water
Old Wolf Lake (1985–95)	Phosphorus	Unknown	Aquatic life, recreation.
Pyrrhotite Creek (Tsolum River) (1985–98)	Copper	Mine reclamation	Aquatic life
Salmon River near Hyder, Alaska (1990–2001)	Cyanide	Uncertain	Aquatic life, wildlife.
Shawnigan Lake (1976–98)	Phosphorus	Unknown	Drinking water, aquatic life, recreation.
Stocking Lake (1985–95)	Phosphorus	Unknown	Drinking water

Source: B.C. Ministry of Environment, Water and Sediment Quality Monitoring Reports, *www.env.gov.bc.ca/wat/wq/wq_sediment.html#data*.

Table 3. Water quality monitoring stations in B.C. showing stable conditions.

Location of monitoring station (years of records)	Concerns monitored (if any)	Cause of past trend (if any)	Water use formerly at risk (if any)
Beaver River in Glacier National Park (1987–95)		No past trend	
Fraser River at Marguerite (1985–2004)	Fecal coliforms	Improved sewage treatment	Drinking water, recreation and irrigation
Fraser River at Red Pass (1985–2004)		No past trend	
Fraser River at Stone (1990–1997)	AOX	Pulp mill waste abatement	Aquatic life, wildlife and their human consumers
Illecillewaet River in Glacier National Park (1987–95)		No past trend	
Iskut River below Johnson River (1981–2002)		No past trend	
Kettle River at Carson (1980–2002)		No past trend	
Kettle River at Midway (1980–2002)		No past trend	
Kickinghorse River above Field (1987–95)		No past trend	
Koksilah River at Highway #1 (1999–2003)		No past trend	
Kootenay River at Creston (1979–2000)	Phosphorus	Dam/reservoir	Aquatic life (declining Kootenay Lake fish production)
Kootenay River at Kootenay Crossing (1987–95)		No past trend	
Liard River at Fort Liard (1984–95)		No past trend	
Liard River at Upper Crossing (1983–94)		No past trend	
Myers Creek at International Boundary		No past trend	
Nechako River at Prince George (1985–2004)		No past trend	
Salmon River at Salmon Arm (1985–2004)	Fecal coliforms	Agricultural non-point source abatement	Recreation, irrigation and livestock watering
Similkameen River at Princeton (1989–97)		No past trend	
Similkameen River near US Border (1979–2000)	Arsenic	Unknown	Aquatic life and drinking water
Skeena River at Usk (1985–94)		No past trend	
Thompson River at Spences Bridge (1985–2004)	Chloride, dioxins & furans in fish	Pulp mill waste abatement	Aquatic life and human and wildlife consumption of aquatic life

Source: B.C. Ministry of Environment, Water and Sediment Quality Monitoring Reports, *www.env.gov.bc.ca/wat/wq/wq_sediment.html#data.*

Table 4. Water quality monitoring stations in B.C. showing deteriorating trends in water quality.

Location of monitoring station (years of records)	Water quality concerns monitored	Cause of trend	Water use at risk
Elk River (1984–2000)	Selenium	Coal mining	Aquatic life
	Nitrogen	Coal mining	Recreation
Fraser River at Red Pass (1985–2004)	Nickel	Natural erosion	None
	Manganese	Surface runoff form highway	Aquatic life
Okanagan River at Oliver (1980–2002)	Chloride	Irrigation return flows	Aquatic life
Quamichan Lake (1973–2001)	Fecal coliforms	Waterfowl	Recreation (swimming)
Quinsam River (1986–2004)	Sulphate & other major ions	Coal mining	Aquatic life - potential effects no direct threats at present
Salmon River at Salmon Arm (1988–2004)	Turbidity, Chloride	Agricultural and forestry non-point sources	Aquatic life, recreation

Source: B.C. Ministry of Environment, Water and Sediment Quality Monitoring Reports, *www.env.gov.bc.ca/wat/wq/wq_sediment.html#data.*

Table 5. New water quality monitoring stations in B.C. added since the previous report (sufficient data is not yet available from these stations for trends analysis)**.**

Location of monitoring station (start year)	Water quality issues or concerns
Callaghan Cr at Callaghan Lake (2004)	Control for increased point and non-point source from Whistler (Olympics)
Callaghan Cr at Highway 99 (2004)	Increased point and non-point source from Whistler (Olympics)
Cheakamus R at Cheakamus Lake Rd (2004)	Control for increased point and non-point source from Whistler (Olympics)
Cheakamus R D/S STP (2004)	Increased point and non-point source from Whistler (Olympics)
Chilcotin R u/s Christie R Bridge (2005)	Impacts of climate change on ice fields and pine beetle harvesting
Columbia River at Nicolson (2003)	Upstream control for Columbia and important wetland
Dean River below Anahim Lake (2006)	Impacts of climate change
Elk River below Sparwood (2002)	Impacts of coal mining
Englishman R at Highway 19 (2004)	Non-point sources (logging, agriculture, urban)
Horsefly River above Quesnel Lake (2006)	Non-point sources (logging, agriculture, mining)
N Alouette R at 132nd (2004)	Non-point source impacts from planned urban development
San Juan River at Island Rd (2004)	Non-point sources (forestry)

Source: L. Swain, B.C. Ministry of Environment, pers. comm.

Results of trend assessments at 38 water quality sampling stations showed 13 improving, 18 stable, and 4 deteriorating. Three other stations had mixed trends. Although the water at Fraser River at Red Pass is close to pristine, the station appears in all three tables because different contaminants had different trends: lead levels were improving while others were stable or, in the case of nickel and manganese, deteriorating. Two monitoring stations appear in two tables: Salmon River at Salmon Arm (deteriorating turbidity from non-point sources, but stable fecal coliform levels) and Fraser River at Marguerite (stable fecal coliforms and improving AOX and chloride levels). Most of the trends are based on ten or more years of data collected from the early 1980s to the 1990s or as late as 2005.

Other monitoring sites showing deteriorating water quality in the measured parameters were Quamichan Lake (fecal contamination from naturally high waterfowl populations), Quinsam and Elk rivers (industrial effluent from coal mining), and Okanagan River at Oliver (increased dissolved solids, possibly from irrigation return flows).

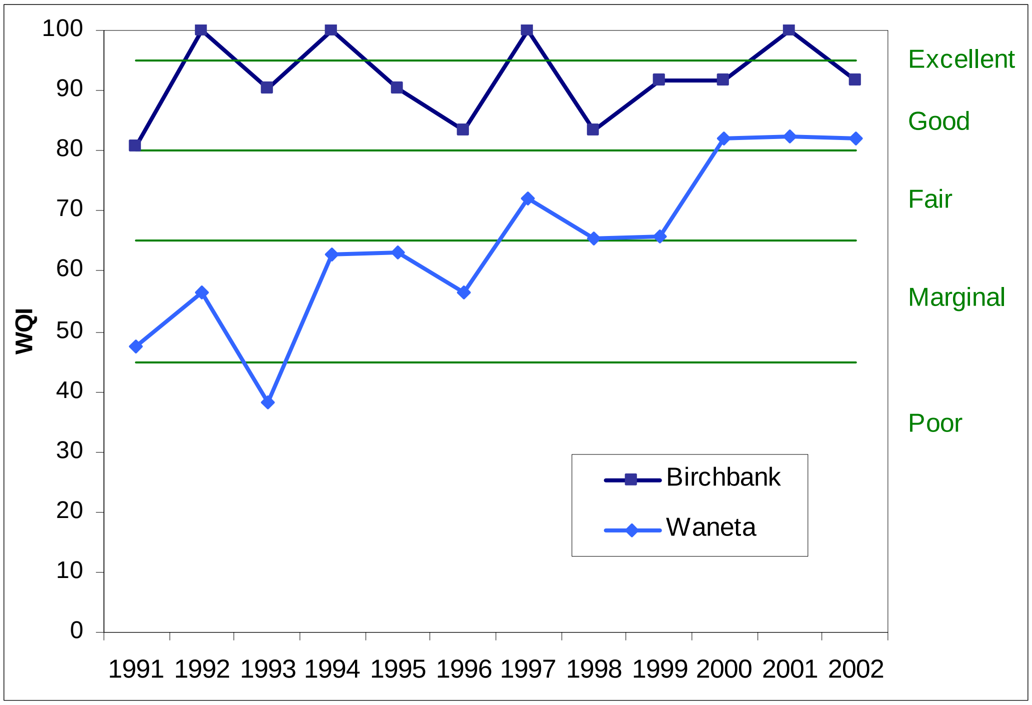
Supplementary Information: Lower Columbia River Water Quality Integrated Environmental Monitoring Program

Formed in 1991, The Columbia River Integrated Environmental Monitoring Program (CRIEMP) was initiated by stakeholders to monitor the Lower Columbia River (that portion between the Hugh Keenleyside Dam west from Castlegar, to the Waneta Dam at the Canada–US border). This 60-km stretch of river is affected by three large dams, by a pulp mill, a sawmill, a smelter at Trail, by municipal wastewater discharges from Castlegar, Trail, and smaller communities, and by non-point sources of contaminants from urban, industrial, and agricultural sources.

The first comprehensive environmental study of the river was released in 1994 (BCMOE 1994b). As a result, industry along the river made major changes that resulted in significant improvement to the environmental quality in the Lower Columbia River. Among them, the Zellstoff Celgar pulp mill upgraded their plant and changed bleaching processes to eliminate discharges of dioxins, furans, and other chlorinated organic compounds. Teck Cominco Metals installed a new smelter, closed a phosphate fertilizer plant, stopped discharging slag to the river, and improved effluent treatment.

Evidence of the effort to reduce impacts on the river can be seen in comparing the water quality index (WQI) scores for two sites over time (Figure 3, Table 6). Water quality at Birchbank, about halfway between Castelgar and Trail, has been rated as Good to Excellent since the early 1990s. In the early 1990s, water quality at Waneta, downstream from Trail near the US border, was rated Poor to Marginal. In the late 1990s water quality at the Waneta site had improved to Fair and in 2000 had improved to Good. The improvement in water quality is likely a result of steps taken to improve and modernize industrial plants and the cessation of discharges from upstream sources (CRIEMP 2005).

Figure 3. Trends in Water Quality Index results for two sites on the Lower Columbia River in January, 1991–2002.



Source: Columbia River Integrated Environmental Monitoring Program.

View graph data in excel.

Table 6. Water Quality Index results for two sites on the Lower Columbia River in January, 1991–2002.

Year (January)	Waneta	Birchbank
1991	47.7 Marginal	80.6 Good
1992	56.5 Marginal	100 Excellent
1993	38.3 Poor	90.4 Good
1994	62.7 Marginal	100 Excellent
1995	63.0 Marginal	90.4 Good
1996	56.4 Marginal	83.5 Good
1997	72.1 Fair	100 Excellent
1998	65.3 Fair	83.5 Good
1999	65.8 Fair	91.7 Good
2000	82.0 Good	91.7 Good
2001	82.5 Good	100 Excellent
2002	81.9 Good	91.7 Good

Source: Columbia River Integrated Environmental Monitoring Program.

3. Key Indicator: Percentage of observation wells that show declining water levels due primarily to human activity

The percentage of observation wells with declining water levels due to human activities is a state or condition indicator. It addresses the question: Is more groundwater being used than can be sustained over time? This indicator is not a direct measure of volume of groundwater withdrawn, but uses changes in groundwater level due to human activity as a surrogate for changes in the supply of groundwater in aquifers due to human activity.

In some areas where available surface water supplies are already fully allocated, (e.g., parts of the Okanagan Valley), unavailable (e.g., some Gulf Islands), are too costly to develop, are of marginal quality, or require expensive treatment, groundwater is often a viable and cost-effective source of water supply. Industry, including manufacturing, mining and aquaculture, is the largest user of groundwater in British Columbia (approximately 55% by volume) followed by agriculture (approximately 20%) and municipalities (approximately 20%) (Berardinucci and Ronneseth 2002).

Water level measurements from observation wells show status and trends in groundwater resources with respect to water availability, replenishment, and use. Groundwater levels depend on recharge to, storage in, movement through, and discharge from an aquifer (aquifers are underground layers of rock and sand containing water). Groundwater storage in an aquifer is affected by the physical properties of the aquifer, such as porosity, thickness, and extent of the geologic deposit or rock comprising the aquifer. Recharge to and discharge from aquifers is affected by short and long-term changes in climate (precipitation and drought events), other natural phenomenon such as infiltration from or discharge to lakes and rivers, groundwater withdrawals, and land use activities. Water level fluctuations from human impacts include domestic and municipal withdrawal, irrigation (both withdrawal from and recharge to aquifers), deforestation, paving, alteration of wet lands, industry, and water impoundments.

This indicator shows only the proportion of observation wells that appear to have decreasing water levels as a result of human activities. It does not show wells that may be affected by human activities that may cause water levels to rise, such as return flow from irrigation practices or effluent disposal. Declining water levels related to human activities are mainly the result of local pumping for industry, agriculture, and municipal and private drinking water supplies.

The indicator is not intended to show whether there are long-term declines in groundwater level due to variations in climate. The main purpose of the observation well network is to monitor effects of pumping withdrawals and other human impacts (for indicators of climate change impacts, see the Climate Change paper in this report).

Methodology and Data

This indicator identifies sites with declining water levels due primarily to human activities by comparing trends in groundwater levels with the precipitation records for the same area. Wells with a pattern of water levels that differs from the pattern of natural climatic variation are likely to be affected by withdrawal of water for human activity. It follows the methodology used in previous reporting for this indicator (BCMOE 2002).

Data on water levels came from monitoring records of observation wells that are part of the British Columbia Observation Well Network. Precipitation data came from climate stations operated by Environment Canada for the area closest to each observation well.

Monthly hydrograph records of water levels were plotted for individual observation wells. The hydrograph trends were then compared to the cumulative precipitation departure (CPD) curves derived from the monthly precipitation data. Hydrographs that mirrored CPD curves were interpreted as reflecting natural seasonal variations. The remaining hydrographs were interpreted as showing impacts from human activity if they did not mirror CDP curves.

By focusing on comparing trends in water levels rather than the absolute water levels, the indicator minimizes two sources of variation.

- Natural seasonal and climatic variations in water levels. For example, there was below-average precipitation and groundwater levels between 1985 and 1990; therefore, water levels in observation wells also declined.
- Natural variation in groundwater levels among wells. Groundwater levels in some aquifers are at the land surface, or even above, in the case of flowing artesian conditions. In other aquifers, water levels may be tens of metres below ground level.

The hydrographs from all available observation wells were examined for each 5-year period (e.g., 2000–2005) to determine whether the overall trend in water level for that period was increasing, decreasing, or stable. Comparison with the CPD curves provided an indication of the degree and net effect of human impacts being observed over the time period examined. The number of wells showing decreasing water levels attributable to human impacts in each 5-year period were plotted as a percentage of the total number of wells monitored during that time. Note that some human activities, such a reduction in water withdrawals, could result in water levels recovering or rising.

Caveats:

- In most cases, it was necessary to make a subjective judgement of the trend in water level in a given well because there was no method to statistically determine trends.
- The time interval selected can affect the results. If the interval is too short, longer-term trends may not show up over short-term fluctuations. If the interval is too long, some trends may not be readily apparent.
- The cut-off date for each interval can affect the results. For example, whether a “peak” appears at the end or the middle of an interval will affect the results for that interval. To check this, for the analysis published in 2002, the trend analysis for each well was done for 5-year intervals shifted by 2 years (e.g., 1967–1972) and for a 7-year interval. Although the results were slightly different, the overall pattern was the same, which provides confidence that the method of analysis gave valid results.

- This indicator uses only change in water level, so wells with levels that drop during a 5-year interval then remain at the lower level will be recorded only as affected during the interval of the initial decline.
- The number of wells sampled varied each year and the spatial distribution of the wells in the network changed over time. This means that apparent trends may be, at least partly attributable to the change in number and location of wells sampled.
- The specific wells sampled have also changed over time as new wells were added to the network and existing wells were dropped from the active list. A list of active wells in the observation well network and the hydrographs for the individual wells are available on the Groundwater Observation Well Network website: *http://srmapps.gov.bc.ca/apps/gwl/disclaimerInit.do*.

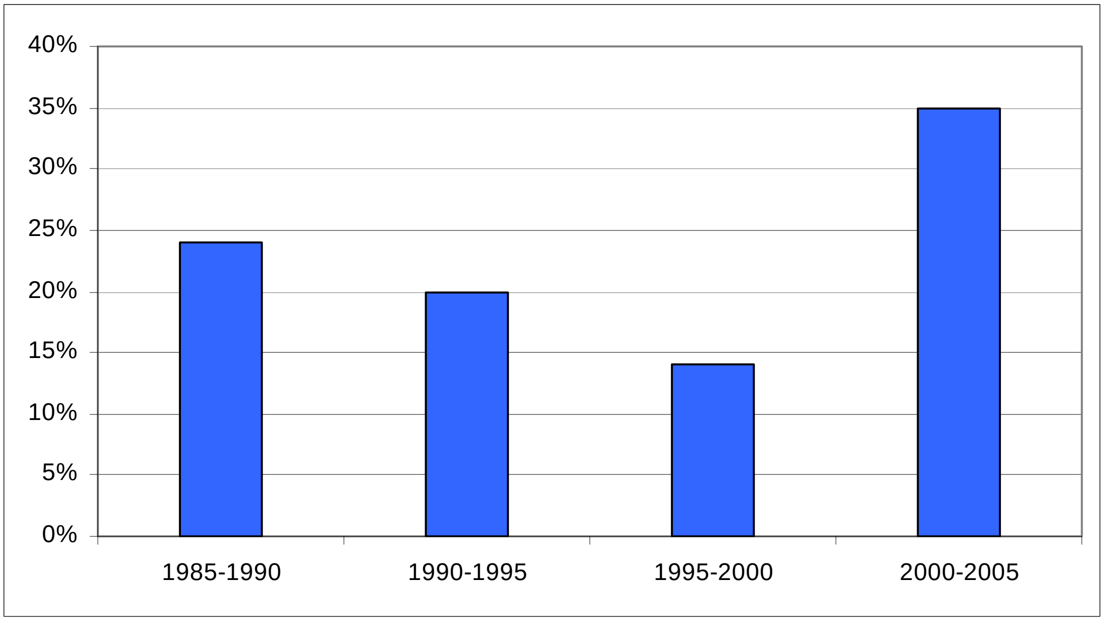
Table 7: Observation wells in B.C. that show evidence of human impacts, 2000–2005.

	Number of wells			
			Showing impact of human activities	
Years	Total	Showing natural fluctuations	with no water level decline*	with water level decline (% of total)
1985–1990	108	23	59	26 (24%)
1990–1995	125	28	72	25 (20%)
1995–2000	139	31	88	20 (14%)
2000–2005	127	50	33	44 (35%)

Source: Ministry of Environment 2007. Data from individual observation wells.

* Examples of human activities that can increase well levels: return flow from irrigation, effluent disposal.

Figure 4. Percentage of observation wells that show declining water levels due to human activities in B.C., 2000–2005.



Source: B.C. Ministry of Environment 2007.

View graph data in excel.

The percentage of observation wells with declining water levels due primarily to human activities was 35% in 2000–2005 (44 of 127 sites with sufficient data) (Figure 4, Table 7). This was a large increase from 14% in 1995–2000. This increase may be attributed in part to enhanced monitoring activities in all heavily developed and highly vulnerable aquifers and areas of quantity concern since the late 1990s. One of the main purposes of the observation well network is to monitor the net effect of human impact (mainly pumping withdrawals); therefore, most observation wells are established close to these areas.

The data show that groundwater levels are not declining everywhere across the province, but rather in local areas where groundwater withdrawal and urban development have been intensive. Among the wells showing water level decline in 2000–2005, 17 (39%) are in the Vancouver Island-Gulf Islands region, 16 (36%) in the Okanagan region, 3 (7%) in the Interior Plateau (Williams Lake-Quesnel-Clinton region, 3 (7%) in the Kamloops-Merritt-Cache Creek areas, and 5 (11%) in five other regions of the province (1 observation well each in Whonnock, Tumbler Ridge, Powell River, Castlegar, and Salmon River).

Although specific information is not available on the quantities of groundwater being pumped, demand appears to have increased significantly in several areas of the province, possibly caused by renewed economic activity and construction of additional private and municipal wells.

4. Secondary Indicator: Number of heavily developed aquifers in B.C.

This is a pressure indicator, showing the current level of stress being placed on groundwater resources by human activities. Groundwater is often the only available or economical source of high quality, potable water for domestic use. Unregulated withdrawal of groundwater, however, can lead to high water use in some areas and lower groundwater levels, which presents a risk to both water supply and quality for nearby well owners. Outside of Victoria and Vancouver Island, groundwater supplies approximately 25% of the total municipal drinking water in the province (BCMOE 1994b). It is economically important to agricultural and industrial users. Groundwater is also an important source of water needed to maintain summer stream flows, which are critical for sustaining fish habitat and other aquatic life and the animals that depend on them.

Heavily developed aquifers are those where the extraction rate is high relative to the natural rate of recharge. Heavy demand puts the supply and quality of groundwater at risk. For example, excessive groundwater withdrawal in coastal areas can cause salt water intrusion into the aquifer. Although instances of water quality problems in local and regional aquifers occur, this is not a direct indicator of water quality in aquifers (see supplementary information, below).

Aquifers are a main source of water for drinking, crop irrigation, industrial processing (e.g., pulp mills) and, in some locations, aquaculture operations such as fish hatcheries. Much of the groundwater demand in British Columbia is from aquifers located near large urban centres and major agricultural areas. In addition, with recent efforts to explore alternative energy sources, groundwater is increasingly being used as a source of low-temperature geothermal energy for heating and cooling buildings.

Methodology and Data

The data for this indicator come from the aquifer inventory of British Columbia developed and maintained by the B.C. Ministry of Environment. The inventory contains 815 aquifers (as of March 2006), and since 2001, 377 aquifers have been added to the inventory. The ministry uses a classification system developed by Kreye et al. (1994) to classify aquifers according to level of development and vulnerability to contamination.

The level of development is determined through an assessment of demand on the aquifer relative to the productivity of the aquifer. Aquifers are categorized as high (I), moderate (II), or low (III) with respect to level of development.

Vulnerability to contamination is considered to be intrinsic to an aquifer. This means that it is based on hydrogeology alone and does not consider the existing type of land use or the nature of a potential contaminant. The vulnerability of an aquifer to contamination from surface sources is qualitative and assessed according to the type of aquifer, thickness and extent of geologic materials overlying the aquifer, depth to water or depth to the top of any confined aquifers, and the type and permeability of aquifer material (e.g., sand and gravel, fractured bedrock). Aquifers are categorized as high (A), moderate (B), or low (C) with respect to vulnerability.

Combining the two variables yields nine classes of aquifers, from IA (heavily developed with a high vulnerability to contamination) to IIIC (low development and low vulnerability). For more information about the aquifer classification system, see the guide by Berardinucci and Ronneseth (2002) available at *www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/aquifers/reports/aquifer_maps.pdf*.

In addition to the basic classification, the aquifer classification system includes a component in which each aquifer is assigned a value. The value is determined by summing the point values from hydrogeologic and water use criteria: productivity, size, vulnerability, demand, type of use, quality concerns (that have human health risk implications), and quantity concerns. The ranking value is used primarily to compare aquifers within a particular class. Each class has lower and higher ranked aquifers, and attention would be focussed on the higher ranked aquifers within the class. Ranking for specific aquifer class are available at: *http://aardvark.gov.bc.ca/apps/wells/jsp/common/aquifer_report.jsp*.

As of March 2006, 64 aquifers were designated as heavily developed (Table 8). Aquifers are found throughout the developed areas of British Columbia; 65% of the heavily developed aquifers are found on Vancouver Island, the Gulf Islands, and the Southern Interior. Although this is an increase from the 35 aquifers reported as heavily developed in 2001, it is not necessarily a negative trend. The increase is primarily the result of more aquifers having been identified and mapped as part of the provincial aquifer monitoring program.

Classifications of aquifers may change if there is a significant increase or decrease in groundwater extraction or an update of new information, such as boundary location. Some aquifers have been downgraded from moderate to heavily developed (e.g., Chemainus and Crofton on Vancouver Island) or upgraded from heavily to moderately developed (e.g., an unconfined aquifer at Rutland). As development increases, or future water quality issues arise, more changes will take place.

Table 8. Number and location of heavily developed aquifers in B.C., March 2006 (includes IA, IB, and IC aquifers).

Region (no. of aquifers)	Aquifers (1 each unless noted)	
Vancouver Island (21)	West Duncan	Thetis Island (2)
	Duncan	Saturna Island (2)
	Panorama Ridge – Chemainus	Mayne Island
	Chemainus and Crofton	North Gabriola Island
	Parksville	Scott Island
	Qualicum	Kolb Island
	Little Qualicum River Valley and Delta	Quadra Island (3)
	Hornby Island (Whaling Station Bay)	McCoy Lake, West of Port Alberni
	Norway Island	
Lower Mainland (12)	Vedder River Fan Aquifer	Green Lake (north of Whistler)
	Abbotsford-Sumas Aquifer	Alpha Lake (Whistler)
	South of Hopington	2 km West of Alpha Lake
	Hopington Aquifer	Gambier Island
	Langley/Brookswood Aquifer	South West Bowen Island (2)
	Belcarra	
Southern Interior (21)	Merritt Aquifer	Spallumacheen (S, of Armstrong)
	Grand Forks Aquifer	Lower Vernon Creek (between Okanagan Lake and Vernon)
	Cache Creek to Scottie Creek	Jim Smith Lake
	Cache Creek to Maiden Creek	East and North of Kelowna (3)
	Semlin Ranch Aquifer	Jaffray
	Sicamous (Mara Lake)	Cranbrook
	Osoyoos Lake to SW Tugulnuit	Wasa Lake
	North of Tuglunuit to Vaseux Lk	Cherry Valley – Kamloops
	District of Lake Country	Clearwater
	Kalamalka Lake to Vernon	
Northern Interior (10)	Lower Nechako River Aquifer	Dog Creek Rd, S. of Williams Lake
	Red Bluff (Quesnel)	Williston Lake (Mackenzie)
	Williams Lake Aquifer	Morfee Lakes (MacKenzie)
	Hill Southwest of Williams Lake	Gerow island Burns Lake
	West of Dragon Lake	North shore Burns Lake

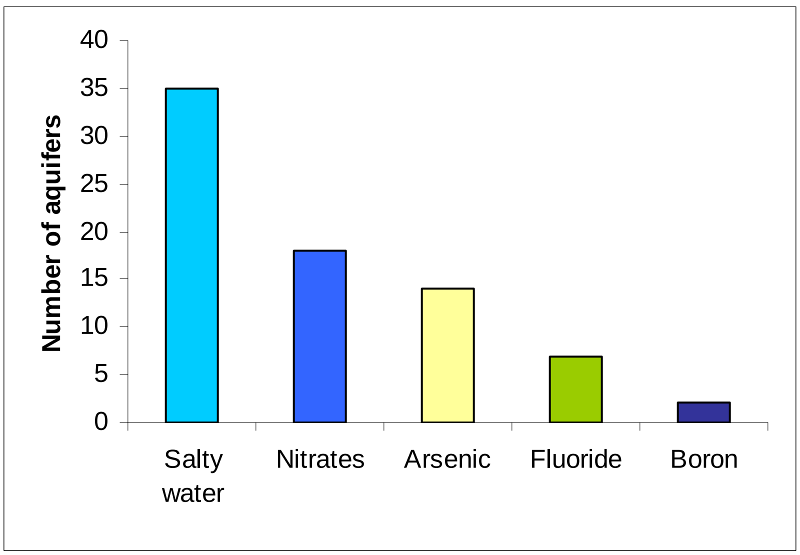
Source: B.C. Ministry of Environment, Science and Information Branch, Watershed and Aquifer Science Section, 2007.

Supplementary Information: Aquifers at risk in B.C.

The aquifer inventory maintained by the B.C. Ministry of Environment identifies aquifers that are vulnerable to contamination and those with documented groundwater quality concerns (c.f. BCMOE 1994a). The most common water quality problem in B.C. aquifers is salty water, followed by nitrate contamination (Figure 5).

Vulnerability, as defined by the aquifer classification system used by the B.C. Ministry of Environment (see Kreye et al. 1994), refers to the intrinsic vulnerability of the aquifer, irrespective of the type and intensity of human activities above it. An aquifer is considered vulnerable to contamination if it is "unconfined" (not overlain by a clay, till or hardpan layer) and if the water table is shallow.

Figure 5. Common water quality problems affecting aquifers in B.C., 2007.



Source: B.C. Ministry of Environment, Groundwater and Aquifer Science Section, 2007.
Note: Figure shows dominant concern; aquifers may have more than one water quality problem.

View graph data in excel.

A count of current aquifers classified as IA (heavily developed with high vulnerability to contamination) and those with water quality concerns documented in Ministry of Environment Watershed and Aquifer Science files at the time the aquifer was classified, showed that of 815 aquifers in the inventory:

28 aquifers are considered heavily developed and highly vulnerable to contamination. Many of these supply drinking water to large communities, such as Langley, Abbotsford, and Prince George (Table 9).

- 53 aquifers have documented health quality concerns (Table 10). Most of these are in the Southern Interior, on the Gulf Islands, the east coast of Vancouver Island, and the Lower Mainland. Thirty-five aquifers reported elevated saline levels, often the result of excessive groundwater withdrawals in coastal regions that causes sea water intrusion into the aquifer. Twelve aquifers, primarily in the Peace River area, also reported very hard water that was unsuitable for drinking water without further treatment.
- 27 of the heavily developed aquifers also have a documented quality or quantity concern (or both) (Figure 6). This is based on files available at the time the aquifer was classified. Other aquifers may also have such concerns, but the information was not available at the time the aquifer was classified.

Although the number of heavily developed, highly vulnerable aquifers and aquifers with reported health concerns has increased over the 18 aquifers identified in 2001, the increase is primarily the result of more aquifers being identified and mapped since then.

The greatest number of aquifers with reported water quality concerns, or those most at risk (classed as IA), are associated with high levels of human settlement. However, health-related water quality concerns have been reported in both heavily developed aquifers and in other vulnerable aquifers that are not heavily developed.

Table 9. Heavily developed aquifers vulnerable to contamination (classified as IA in B.C. Ministry of Environment aquifer inventory as of March 2006).

Region (no. of aquifers)	Aquifer	
Lower Mainland (6)	Vedder River Fan	Langley/Brookswood
	Abbotsford-Sumas	Belcarra
	Hopington	Green Lake (Whistler)
Vancouver Island (9)	Duncan	North Gabriola Island
	Chemainus and Crofton	Thetis Island (2)
	Whaling Station Bay (Hornby Is.)	East Saturna Island
	Little Qualicum R. valley and delta	Kolb Island
Southern interior (10)	Grand Forks	Spallumacheen (South of Armstrong)
	Merritt	Kalamalka Lake to Vernon
	Cache Creek	Jaffray
	Osoyoos Lake to SW Tugulnuit Lake	Wasa
	North of Tugulnuit Lake to Vaseux Lake	Clearwater
Northern Interior (3)	Lower Nechako	Morfee Lakes (Mackenzie)
	Red Bluff	

Source: Ministry of Environment, Science and Information Branch, Watershed and Aquifer Science Section 2007.

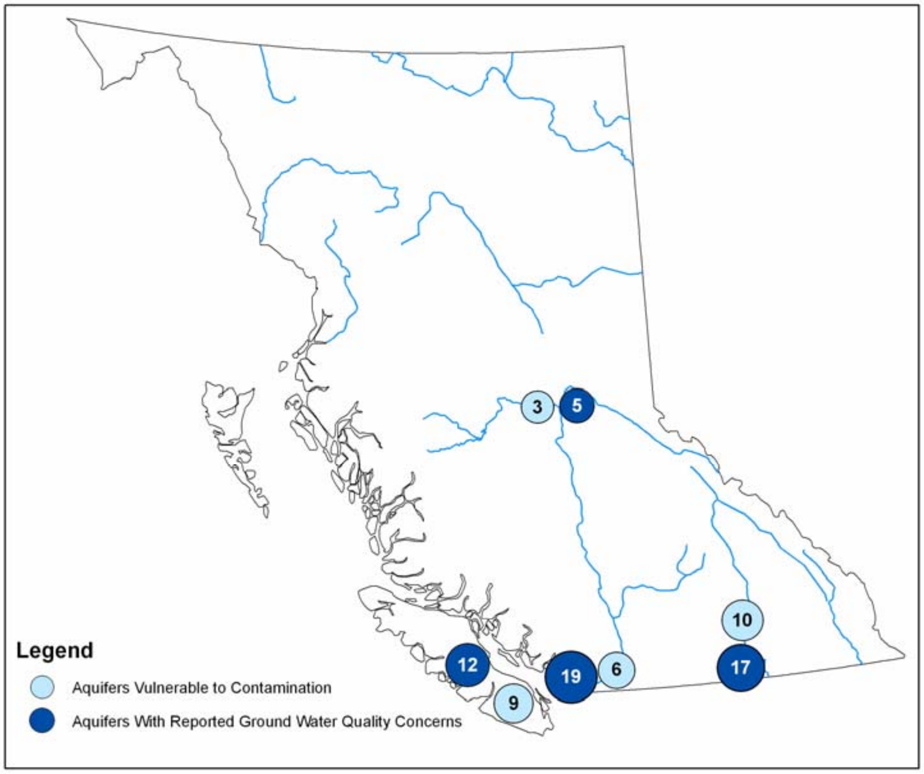
Table 10. Aquifers with reported groundwater quality concerns (as of March 2006).

Regions (no. of aquifers)	Aquifer	
Lower Mainland (19)	Abbotsford-Sumas Aquifer	McMillan Island
	Mount Lehman	Columbia Valley Aquifer
	Grant Hill Bedrock Aquifer	Coquitlam River Floodplain
	Aldergrove	Gambier Island (2)
	Hopington	Sechelt (2)
	Langley/Brookswood	Halfmoon Bay
	Boundary Avenue near Border	Mixel Lake
	South of Hopington	Kleindale
		Bowen Island
Vancouver Island (12)	Scotch Creek	Comox Harbour to Merville
	Cedar, Yellow Point, North Oyster	Port Renfrew
	Mayne Island (2)	Colwood, Langford, Metchosin
	Keats Island	North shore Sproat Lake
	East Saanich Peninsula	McCoy Lake, Port Alberni
		Saturna Island
Southern Interior (17)	Merritt Aquifer	Lower South Thompson
	Grand Forks Aquifer	Osoyoos Lake to southwest Tugulnuit Lk
	Osoyoos West Aquifer	North of Tugulnuit Lake to Vaseux Lake
	Osoyoos East Aquifer	Mouth of Trout Creek (Summerland)
	Osoyoos East Confined Aquifer	Cranbrook
	Scotch Creek	St. Mary River
	Meyers Flat	Deadman Valley
	Marron Valley	
	Oyama	
	Deep Creek (North of Armstrong)	
Northern Interior (5)	Northeast of Quesnel	Taylor Flats
	108 Mile Limestone Aquifer	Fort St. James
	Progress	

Source: Ministry of Environment, Science and Information Branch, Watershed and Aquifer Science Section 2007.

Note: Water quality concerns were documented when records were entered into the provincial aquifer inventory; the present water quality status of aquifers may differ.

Figure 6. Aquifers vulnerable to contamination and with reported groundwater quality concerns.



Source: Ministry of Environment, Science and Information Branch, Watershed and Aquifer Science Section 2007.

5. Secondary Indicator: Daily municipal water use per capita in B.C.

The average daily consumption of municipal water per capita is a pressure indicator. It shows the demand that municipal water use is placing on British Columbia's supply of fresh water. This indicator addresses the question: What are the trends in individual water use in B.C.? Municipal water use includes water used for residential (domestic), industrial, commercial, and other uses. Residential water use is only a portion of municipal water use, accounting for about half of municipal water use nationally.

Current water use patterns in British Columbia can have environmental and economic consequences, including seasonal water shortages. Excessive water use can draw down natural water flow levels and reduce the natural ability of aquatic ecosystems to deal with pollutants. Increased water use also dilutes wastewater, reducing wastewater treatment efficiency and effluent quality. Excessive water use increases the cost of providing drinking water treatment and supply infrastructure.

Methodology and Data

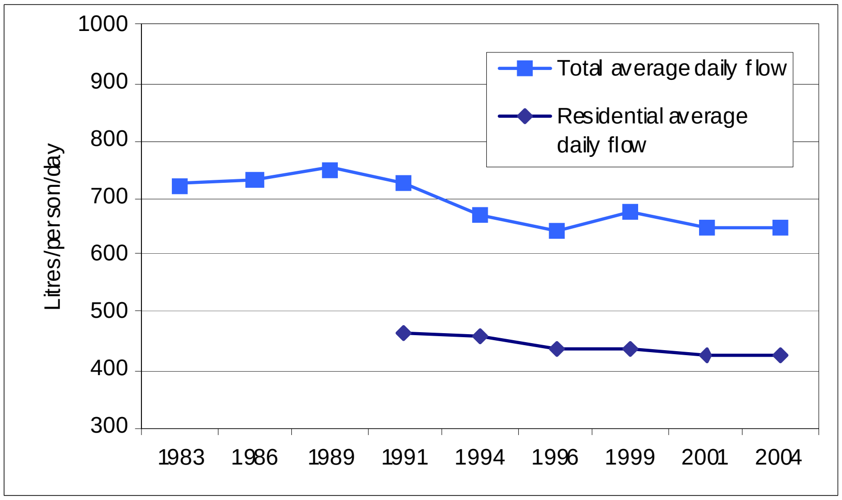
The Municipal Water and Wastewater Survey (MWWS) of Environment Canada collects water and sewage data for municipalities at 5-year intervals. Before 2001, the survey (formerly the Municipal Water Use and Pricing Survey or MUD) was restricted to communities with a population of 1,000 or higher. In 2001, the methodology was changed to include a representative sample of 660 communities with fewer than 1,000 residents each. However, for the summary information shown in this indicator, these data were excluded in order to allow comparison with MUD data from earlier years. In 2004, 777 communities responded completely or almost so, down from the 880 communities in 2001. This is a relatively low response rate and the survey responses were supplemented with call-backs to large municipalities for additional or missing information. Values for some missing data were calculated, based on previous years' data after adjusting for population changes over time. This brings the effective response rate up to 1,418 municipalities, representing 28.9 million Canadians (Environment Canada 2007b).

The MWWS data used for this indicator were:

- Average daily flow (ADF): This is the water reported as used by a municipality. The total ADF is the sum of all water used, including residential, industrial, commercial, and other purposes (the latter includes losses). The residential ADF is an estimate of residential use, separate from commercial, industrial and 'other' purposes.
- Municipal population served water: This is the population in the municipality served by any water system. MWWS uses Statistics Canada population estimates for census and non-census years where possible. It does not include populations external to the municipality.

The figures for water use per person in B.C. (Figure 7, Table 11) were calculated by totalling the average daily flow (in cubic metres per day; 1 m^3 = 1,000 litres) and dividing it by the total municipal population served water. Previous environmental trends reports have reported only the total ADF, divided by population, to arrive at per capita figures; therefore, these are included in this report (Table 11). The estimated residential ADF per capita is also reported because per capita estimates actually apply only to residential use rather than commercial or industrial use.

Figure 7. Per capita municipal water use in B.C., 1983–2004. Total average daily flow used by municipalities and estimate of residential component.



Source: Environment Canada, Municipal Water Use Database, and Municipal Water and Wastewater Survey database.

View graph data in excel.

Table 11. Per capita municipal water use in B.C., 1983–2004.

Year	Total average daily flow (litres/person/day)	Average daily residential flow (litres/person/day)
1983	722	–
1986	732	–
1989	752	–
1991	726	465
1994	672	459
1996	642	440
1999	678	439
2001	651	425
2004	649	426

Source: Environment Canada, Municipal Water Use Database and Municipal Water and Wastewater Survey database.

Note: Residential average daily flow is reported separately and is also included in the total average daily flow.

MUD and MWWS survey records show an overall decrease in the municipal water use per capita since 1983. One factor contributing to the decline in residential water use may be the introduction of education and incentive programs to improve water conservation. Over the last decade, municipalities and regional districts in B.C., have been increasing efforts to inform the public about water conservation through workshops and public advertising. The Greater Vancouver Regional District and Capital Regional District have also offered cash rebate incentive programs to replace older equipment such as toilets, washing machines, or irrigation equipment with more efficient models, and most municipalities have instituted restrictions on summer water use. Programs for businesses include an incentive rebate to replace water-cooled equipment, water audit programs, and education materials for hotel guests.

The total ADF and residential ADF per capita for B.C. continues to be above the national average (Table 12). In 2004, the total ADF was 609 litres per person in Canada, while in B.C. it was 649 litres per person; residential ADF was 329 litres per capita nationally, while in B.C. it was 426 litres (Environment Canada 2007a). The higher rate of water consumption in British Columbia may be a result of the flat rate pricing systems still in use in most B.C. municipalities. Users with water meters pay according to volume of water used, while those without metering pay a flat rate for generally unlimited access to water services. B.C. has the largest population with flat rate pricing systems of all provinces and is one of the provinces with the lowest proportion of residential users having water meters. Although the percentage of the municipal population in B.C. with water meters increased from 22% in 1991 to 30% in 2004, the majority of British Columbians (70%) still pay a flat rate for water service (Environment Canada 2007a).

Table 12. Municipal water use in Canada, per capita, 2004.

Province / Territory	Total average daily flow (litres/person/day)	Residential average daily flow (litres/person/day)
Newfoundland & Labrador	780	501
PEI	569	238
Nova Scotia	546	321
New Brunswick	1384	438
Quebec	848	424
Ontario	481	260
Manitoba	466	219
Saskatchewan	516	303
Alberta	488	271
B.C.	649	426
Yukon	932	645
NWT	437	257
Nunavut	134	113
National Average	609	329

Source: Environment Canada 2007b; Municipal Water and Wastewater Survey 2004 Summary Tables, *www.ec.gc.ca/water/MWWS/pdf/MWWS_2004_Tables_En.pdf.*

Table 13 shows how B.C. and Canada compare to other developed countries in residential/domestic water consumption per capita. Definitions and estimation methods employed by these countries vary considerably and change over time, making water use comparison difficult, therefore these figures are presented as a rough comparison only. B.C. has a higher domestic consumption rate than all of the countries listed in the table, well above the worst performer (the United States) and four times higher than the estimated domestic water use from the lowest consuming countries.

Table 13. Domestic water use per capita for selected countries.

Country	Domestic water use (litres/person/day)
British Columbia	426*
United States	380
Canada	335*
Italy	250
United Kingdom	200
Sweden	200
France	150
Israel	135

*Source: Environment Canada. 2004. Water Use: Residential average daily flow per capita. Other data: Environment Canada, Freshwater website *www.ec.gc.ca/water/images/manage/use/a4f4e.htm*.

WHAT IS HAPPENING IN THE ENVRONMENT?

The overall quality of most surface water bodies monitored in B.C. is good or stable, and most of the mapped aquifers in the province are not heavily developed. However, the indicators in this paper show that the fresh water resources, including surface water and groundwater, in British Columbia are under pressure from increasing human population and economic activity.

- According to the national standard Water Quality Index more than half of monitoring stations in B.C. are in good or excellent condition; 39% of stations are in fair condition, only 10% are marginal, and none are in poor condition. Because most monitoring stations are located where there is a risk of pollution from industrial discharge, mining, forestry, or other human activities that can affect water quality, is likely that a much greater proportion of the thousands of other B.C. water bodies are actually in good or excellent condition.
- Trends in surface water quality, for monitoring stations largely located in areas of greatest human impacts, showed 13 stations with improving trends, 18 with stable trends, and 4 with deteriorating trends. Three other stations had mixed trends.
- An increasing proportion of observation wells show a trend of decreasing in water levels as a result of impacts from human activity. For the 5-year period up to 2005, 35% of the wells showed a trend of declining in water levels that was not correlated with natural variations in precipitation. This increase over previous years may be a result of increased monitoring in

the most heavily developed and vulnerable aquifers and in areas where there are currently concerns about water supply.

- As of March 2006, records from the provincial aquifer monitoring program show 64 heavily developed aquifers of the 815 aquifers mapped. This was up from the 35 heavily developed aquifers recorded in 2001, mainly because more resources have been allocated to identifying and mapping aquifers in the intervening years. There are 27 heavily developed aquifers with documented water quality problems, such as salt water intrusion and very hard water, that make them unsuitable for drinking water.
- Water use patterns in B.C. show a decrease in the estimated residential water use per person from 465 litres/person/day in 1991 to 426 litres in 2004. This continues to be above the Canadian national average of 329, putting B.C. in the top bracket of water-using provinces.

Protecting drinking water quality and maintaining the integrity of aquatic ecosystems are important environmental issues. Ongoing monitoring, protection, and careful management of these water resources are of critical importance. British Columbia has an abundance of surface water in lakes and streams compared to other parts of the world, but increasing population and economic activity in the province is escalating the pressure on water supplies, both from pollution and from withdrawals of water. As the provincial population continues to grow and demands on groundwater supplies increase, there is a corresponding need to protect and manage the resource.

WHAT IS BEING DONE ABOUT IT?

Federal-Provincial Initiatives

Canadian Council of Ministers of the Environment Water Quality Initiatives: The federal government works with the provinces and territories to develop national, science-based, voluntary guidelines for water quality (*www.ec.gc.ca/CEQG-RCQE/English/Ceqg/Water/default.cfm*). The provinces and territories use these guidelines when creating their own enforceable standards, objectives, or guidelines. British Columbia is part of the federal-provincial CCME initiative to improve the national Water Quality Index and water quality guidelines, and to develop larger and more representative water monitoring networks. Reported through CCME but developed through the Federal-Provincial-Territorial Committee on Drinking Water, the Canadian Drinking Water Quality Guidelines establish maximum acceptable concentrations for substances in water used for drinking (*www.hc-sc.gc.ca/ewh-semt/water-eau/drink-potab/index_e.html*). To date, guidelines have been established for more than 85 physical, chemical, and biological attributes of water quality. Other water quality guidelines have been produced for aquatic life, wildlife, agriculture, and recreational uses.

CCME is currently developing a national strategy for municipal effluents to ensure that consistent levels of treatment are provided across Canada. This strategy also includes the requirement to meet effluent objectives developed from the national CCME water quality guidelines.

Federal-provincial reporting: Environment Canada and the provinces and territories work together to produce annual reports on national water quality. Reports based on protection of aquatic life were released in 2005 and 2006 and will continue until 2009. A recent example: The British Columbia and Yukon Territory Water Quality Report 2001–2004 (Environment Canada et al. 2007) *www.env.gov.bc.ca/wat/wq/bcyt_wqrep_01_04/bcytwqrep_01_04.pdf*.

Provincial Government Regulations and Initiatives

In addition to current work on developing a provincial water action plan (c.f., BCMOE 2007), many other provincial government regulations, monitoring, and educational activities support stewardship of water resources in British Columbia.

BC Drinking Water Protection Act: In 2002, the provincial government published an Action Plan for Safe Drinking Water in British Columbia. (*www.healthservices.gov.bc.ca/cpa/publications/safe_drinking_printcopy.pdf*)

As part of the plan, the government has improved drinking water source protection through the *Drinking Water Protection Act* (2001) and the amended Regulation (2005) *www.qp.gov.bc.ca/statreg/reg/D/200_2003.htm*. The Act generally covers all water systems other than single family dwellings. It outlines requirements for water suppliers to ensure that water supplied to their users is potable and meets any additional requirements established by the Drinking Water Protection Regulation. It has provisions for Drinking Water Protection Plans, which are regulatory plans that may be done where there are demonstrated risks to human health from drinking water (none had been completed as of June 2007). Provincial reports on drinking water protection are available at *www.health.gov.bc.ca/protect/dwpublications.html*.

BC Water Act and Groundwater Protection Regulation: In British Columbia the allocation of water is regulated under the Water Act. The Act authorizes the licensing of diversion, storage, and use of water from streams, lakes, and springs; it regulates works that may be constructed, and requires changes in and about a stream to be approved. The province is currently involved in seeking consensus on a new water allocation model and modifying and streamlining the Water Act and related legislation.

Although groundwater withdrawals are not regulated under the *Water Act*, the Ground Water Protection Regulation (2005) introduced standards for well construction and management to protect the resource. Phase 2 of the Ground Water Protection Regulation is being developed and will include additional standards for wells and well pumps, requirements for siting, testing, and reporting of wells, and controlling artesian flow.

BC Water Management Plans: In 2004, Part 4 of the *B.C. Water Act* came into force to allow some aspects of water management to be addressed through water management plans. These are area-based plans that address or prevent risks to water quality, conflicts between users, and between users and instream uses. The plans can apply to both surface water and groundwater. The Minister of Environment initiates the plan, which is developed in accordance with terms of reference through stakeholder and public consultation. Once complete, the plan is submitted to the Minister of Environment, then to the provincial Cabinet for approval.

Approved plans are legally enforceable. An approved water management plan is implemented by regulation and may restrict activities such as well drilling, and have an impact on decisions made under other legislation, including zoning bylaws. Plans would only be developed in critical areas when other regulatory and non-regulatory approaches have not successfully addressed water resource problems.

A pilot Water Management Plan under the provisions of Part 4 of the *Water Act* is being developed in the rapidly growing Township of Langley. The area is characterized by a mix of urban and rural land use that is heavily dependent on groundwater supplies for agricultural, domestic, commercial, and industrial uses. About half of the municipal water supply and all of the rural supply comes from groundwater. Monitoring shows that groundwater levels in intensively used aquifers are declining, primarily due to over-extraction of groundwater. There have also been local occurrences of poor water quality due to nitrates, arsenic, coliforms, iron, and manganese.

In 2002, the Township of Langley adopted a Water Resource Management Strategy to ensure safe drinking water, maintain adequate water supplies, and protect environmental values such as fish habitat. It is anticipated that the Langley plan will be completed by December 2007. If approved by Cabinet, implementation and compliance strategies will be developed in 2008/09.

BC Hydro Water Use Plans (WUPs): In 1996, the B.C. government created a new water use planning process as part of licensing under the *B.C. Water Act* for BC Hydro's hydroelectric power and other water control facilities. WUPs take into account multiple uses for the resource as well as social and environmental values. As much as possible, the goal of the process is to achieve consensus on a set of detailed operating rules for each dam or other facility that satisfies the range of water use interests at stake. WUPs are prepared through a collaborative effort involving the licensee, government agencies, First Nations, other key interested parties, and the general public. They are developed to balance the range of interests, such as fish and aquatic habitat, power generation, flood control, and in some cases, recreation and heritage resources. WUPs specify the operating conditions relating to water licences issued under the Water Act. A WUP is implemented by an order of the Comptroller of Water Rights.

As of 2007, 23 BC Hydro Water Use Plans have been developed. Of these, 18 plans have been implemented, and approval for the remaining 5 plans is expected by the end of 2007.

More information is available at *www.env.gov.bc.ca/wsd/plan_protect_sustain/water_use_planning/index.html*.

B.C. Ministry of Environment initiatives: Responsibility for monitoring water resources and supporting stewardship of water resources rests with this ministry in the provincial government. The ministry:

- Increased funding for water quality monitoring to be undertaken under the Federal-Provincial Water Quality Monitoring Agreement. Funds are going toward drilling additional groundwater observation wells and modernizing data collection techniques, including transfer of real-time data using telemetry.

- Signed a Memorandum of Understanding with Natural Resources Canada to conduct regional groundwater assessments in BC. Assessments of regional aquifers is currently taking place in the Okanagan Basin.
- Is in the process of reviewing the Observation Well Network. A review was completed for Okanagan Basin and staff are currently implementing recommendations to enhance monitoring. Reviews of the Observation Well Network will be conducted in other areas of the province on a priority basis.
- Is creating a toolkit to support decision-making in areas affected by the mountain pine beetle infestation, in collaboration with the Ministry of Forests and Range. Changes in water flows, stream temperature, sedimentation, and other factors in beetle-killed forests affect water resources for people and wildlife dependent on aquatic ecosystems. The tool kit is for use by industry, government, First Nations, and communities as they make decisions around salvage activities, restoration planning, and community preparedness.
- **B.C. Water Conservation (Plumbing) Regulation**: In 2005, a revised Plumbing Regulation took effect that requires all new toilets installed in areas of the province specified in the regulation must be 6-litre, low-consumption models. The regulation applies to 39 geographic areas, including the populated areas of Vancouver Island (such as the Capital, Cowichan Valley, and Nanaimo regional districts), Lower Mainland (Metro Vancouver, Gibsons), and the more populated areas of the central interior. In areas not specified for low-consumption toilets, the regulation requires that new installations use fixtures with flush cycles no greater than 13.25 litres. More information at *www.housing.gov.bc.ca/building/Low_Consumption_Toilets.htm*.

Other Water Sustainability Initiatives in BC

Water Sustainability Action Plan (WSAP) for British Columbia: This plan was introduced in 2004 and is a key initiative to improve awareness, build capacity, and encourage action around the sustainable use of water resources and water stewardship in British Columbia. (See *www.waterbucket.ca/waterbucket/dynamicImages/386_WaterSustainabilityActionPlanforBC.pdf)*

The WSAP is coordinated and delivered by the Water Sustainability Committee, a partnership of government and non-government organizations chaired by the British Columbia Water and Waste Association. The WSAP promotes integrated "water-centric" planning at all levels through six interconnected programs: the WaterBucket website Partnership; the Water$ave Tool Kit for British Columbia; Convening for Action – Roundtables on Water Sustainability; the Green Infrastructure Partnership; the Water Balance Model for British Columbia; and Watershed/Landscape-Based Approaches to Community Planning. Accomplishments to date include the following:

- The WaterBucket website (*www.waterbucket.ca/*). Launched in 2005, this website is a key communication tool for the Water Sustainability Action Plan. It provides a 'one-stop' portal to a comprehensive set of information resources and planning tools. Among other goals, the website is intended to address concerns of many water suppliers and managers in B.C. over future limits to water supply, given population growth and drought conditions experienced in recent years. The website now has seven communities-of-interest: Water-Centric Planning;

Water Use and Conservation; Rainwater Management; Green Infrastructure; Agriculture and Water; Convening for Action; and Small Community Infrastructure Sustainability.

- The Water Balance Model for British Columbia. This is a web-based evaluation tool that quantifies the benefits of installing rainwater source controls such as green roofs, rain gardens, and infiltration facilities under different combinations of land use, soil type, and climate conditions. Early success in British Columbia led to the decision in 2004 to create a national Water Balance Model for Canada at *www.waterbalance.ca*.
- The Water$ave Tool Kit for BC. This resource has posted more than 50 province-wide success stories in the Water Use and Conservation Community-of-Interest pages on the Waterbucket website.
- Convening for Action pilot programs in the South Okanagan, Vancouver Island and Metro Vancouver promoting "water balance/water centric" approaches to rainwater management for community planning and land development. Experience from these pilot programs will be used to draft a provincial Water-Centric Planning Guidebook.
- Green Infrastructure Partnership workshops in 2004 and 2005 promoted the benefits of a "design with nature" approach to sustainable community planning and land development.

Local Planning: Beyond water planning processes done under a regulatory framework, there are a variety of locally led initiatives under way in BC. These planning initiatives are led by local government or an interest group to address specific problems with water quantity or quality. The success of such non-regulatory plans depends on how well all parties adhere to the voluntary plan recommendations. Some examples include:

- In the Okanagan, several processes have been undertaken to address the issue of community water supply and fisheries conflicts. Locally led water plans have been developed for Trout Creek, Trepanier Creek, and one is underway for Mission Creek. An extensive study of water supply and use is being undertaken for the Okanagan Basin *www.obwb.ca/water_supply_demand/*.
- On Vancouver Island a plan has been developed for the Cowichan Basin (Cowichan Basin Water Management Plan, *www.cvrd.bc.ca/water_cowichan/index.htm*). Initially driven by fisheries interests, this plan has expanded to include more issues and is now being championed by the regional district as a tool to help guide future growth. Campbell River also has developed a plan for the community watershed.
- Other examples are the Nicola Water Use Management Plan to address water supply management for fish, as well as agricultural water use conflicts, and the City of Chilliwack groundwater protection plan (*www.chilliwack.com/main/page.cfm?id=205*).

The Water Sustainability Project (WSP): This project began in January 2003 at the University of Victoria POLIS Project on Ecological Governance. The focus of the WSP is to provide an understanding of the dynamics of urban water use and to promote demand management and ecological governance as part of the broader goal of sustainable water management. The project has produced detailed studies of water use in Canada, and developed a comprehensive legal and policy framework for urban water management and action plans for federal, provincial, and municipal governments. A key objective is increasing public awareness around the importance and limits of water in Canada. (*www.waterdsm.org/index.htm*)

WHAT YOU CAN DO

Individuals can take many small and large actions to protect surface water from pollution and reduce the amount of water used from aquifers and other sources.

Ways to protect water quality:

- Reduce your use of household hazardous products (cleaning products, pesticides, solvents, etc.) and use less harmful alternatives, such as phosphate-free soaps and detergents.
- Never dispose of such products where they can enter storm drains. If possible, take them to recycling or collection centres. For locations see the Recycling Council of B.C. *www.rcbc.bc.ca/* or call: 1-800-667-4321.
- Regularly check and repair fluid leaks from your vehicle. If you service a vehicle yourself, be sure to recycle used oil and antifreeze.
- Reduce or eliminate use of fertilizers and pesticides on your lawn and garden. Use slow-release fertilizers, non-persistent pesticides, and natural pest control products instead.
- Compost your kitchen waste and other organic matter and recycle the compost to gardens.
- For onsite sewage systems, septic tanks should be inspected and pumped out every 3 to 5 years. Don’t put toxic chemicals or solids down the drain (i.e., avoid garbage disposal units). Keep vehicle traffic and heavy objects off your septic field. If the field is covered with a lawn, avoid overwatering.

Conserve water indoors:

- Install low-flow toilets (save 6 to 14 litres per flush) or install water displacement devices in toilets.
- Install low-flow showerheads and faucets.
- Check all taps and fixtures for leaks.
- Take shorter showers or use less water in baths.
- Run dishwashers only when full, rather than wasting water on a partial load.
- Use short cycles and full loads in washing machines.
- Purchase water-conserving washing machines and dishwashers when it is time to replace appliances.

Conserve water outdoors:

- Make sure watering systems do not leak.
- Let lawns go dormant in the summer, watering only once in months with no rain.
- Water in the morning or evening to reduce loss to evaporation.
- Use drip irrigation systems for garden plants and be careful not to over-water.

- Choose drought-tolerant plants; group plants with the same water needs together.
- Keep soil around plants covered with leaves or other organic mulch.
- Use a bucket of soapy water to wash your car, then rinse quickly using a hose.
- Sweep sidewalks and driveways rather that using water to spray them clean.

Check your regional district for information on rebate and incentive programs and other local information:

- Greater Vancouver Water District Water Conservation programs and information are available at *www.gvrd.bc.ca/water/conservation.htm*. This site includes information on how to conserve water, check for leaks, choose models of low-flush toilets and other fixtures, rebate and incentive programs, and provides tips for conserving water (GVRD 2006) *www.gvrd.bc.ca/water/pdfs/WaterConservationTips.pdf*.
- Capital Regional District Water Conservation programs and information are available at *www.crd.bc.ca/water/conservation/*. This site includes information on how to conserve water, and on rebates and incentive programs for residential users and businesses.

Participate in community efforts:

- Join or form a community stewardship group to care for a local water body. For watershed groups near you, see *http://stewardshipcanada.ca or http://waterquality.ec.gc.ca*.
- Participate in local community planning and regional growth strategies.
- Encourage your neighbours, local employers, and community leaders to implement water quality protection measures.

More Information

Environment Canada has a comprehensive website with information on what individuals can do to protect water resources, conserve energy, and take other steps to protect the environment. Separate webpages provide information on activities at home, work, school, on the road, and for recreation (cottages, boating, etc.). See *www.ec.gc.ca/eco/main_e.htm*.

The Canada-British Columbia Farm Planning Program has produced an Environmental Farm Planning Reference Guide for stewardship on farms and ranches, including a section on protecting water resources. See *www.agf.gov.bc.ca/resmgmt/EnviroFarmPlanning/EFP_Refguide/refguide_toc.htm.*

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